Chapter 10
Water Supply Systems

10-1. General

a. Water supply. The water supplies covered in this chapter provide water for the following requirements:

(1) Generator air coolers and bearing coolers.

(2) Turbine bearing coolers, wearing rings, and glands.

(3) Transformer cooling.

(4) Fire protection.

(5) Potable water (domestic water).

(6) Air conditioning systems.

(7) Pump bearing prelube.

(8) Compressors and aftercoolers.

(9) Deck washing.

The various requirements are divided into several powerhouse systems for convenience in coverage. However, powerhouse and project requirements, interconnection of systems, and suitable water sources vary from project to project, and the designer will be required to apply the information noted to the best advantage for each particular powerhouse. General piping requirements for all systems are covered in Chapter 17, "Piping."

b. Zebra mussel. It is expected that zebra mussels (Dreissena polymorpha) will eventually infest all major fresh water bodies of the continental United States except the southernmost portion of the Gulf Coast states. ETL 1110-2-333 provides monitoring guidance for determination of presence/absence of zebra mussels and collection of information for detailed studies of zebra mussel populations. Technical Note ZMR-3-05 provides control strategies for zebra mussel infestations of various hydropower plant components.

10-2. Generator and Turbine Cooling Water System

a. General. The generator and turbine cooling water system provides cooling water for generator air coolers, generator and turbine bearing oil coolers, and when of suitable quality, the turbine glands and wearing rings. The overall system is a joint design effort involving the water supply, discharge, and external equipment determined by the powerhouse designers, as well as the unit requirements and equipment determined by the generator and turbine manufacturers. Close coordination between the design responsibilities is required.

b. Water requirements.

(1) Cooling water. The water flow requirements are determined by the generator and turbine suppliers but are dependent in part on water supply temperatures furnished by the powerhouse designers. The temperatures should be verified by all available sources and take into account the extremes in climate conditions for the site. Flow requirements are usually large, in the 25-100-L/s (400-1,600-gpm) range for typical units, requiring major, dependable sources. Purity requirements are moderate, permitting nonpotable supplies with limited silt in suspension.

(2) Gland and wearing ring. Gland and wearing ring flow requirements must be obtained from the turbine supplier. Turbine contracts require the supplier to furnish these figures, and turbine guarantees are in part dependent on the stated flows being provided. Previous projects show little correlation between unit size and shaft size or speed with required flows. However, they can total a significant demand as stated requirements have been up to 3 L/s (35 gpm) or more per unit. Rough figures should be obtained in the preadvertising correspondence that takes place with prospective turbine bidders, and final water supply design should be based on turbine contract figures. Quality requirements are nominal requiring only the removal of abrasive material.

c. Sources.

(1) Spiral case. For units with heads up to about 76 m (250 ft), the preferred source of cooling water is a gravity supply from an inlet in the spiral case or spiral

case extension. In multiunit plants, an inlet is provided for each unit with a crossover header connecting all units to provide a backup water supply to any one unit. Crossovers between pairs of units only are not regarded as adequate since there would be no emergency source from an unwatered unit. The spiral case source is usually satisfactory for unit bearing coolers, as well as the generator air coolers, and can be adequate for gland and wearing ring use with proper filtering and adequate head.

(2) Tailwater. For higher head projects, above 76 m (250 ft), the usual source of cooling water is a pumped supply from tailwater. This normally provides water of essentially the same quality as the spiral case gravity system.

(3) Other sources. It is unlikely that other suitable sources will be available or required for cooling requirements, but alternate sources should be considered for gland requirements. Silt or other abrasive material is usually present in varying degrees in reservoir water, at least seasonally, and since abrasive material is injurious to glands, an alternate source or additional treatment is usually required. The potable water system is normally the best alternate if the supply is adequate or could be economically increased. This would usually be in the case of a well supply requiring little chlorination. Where potable water is used, cross connections from the cooling water source, with backflow protection, should be provided for emergency use.

d. Head requirements. Normally the cooling water supply should provide a minimum of 68.9-kPa (10-psi) differential across the connection to the individual cooler headers. Available gravity head, cost of a pumped supply, and cost of coolers all enter into an optimum cooler differential requirement and require early design consideration to assure a reasonable figure for the generator and turbine specification. Gland and wearing ring differential head requirements should be obtained from the turbine supplier.

e. Treatment. Water for coolers, glands, and wearing rings will normally require only straining or filtration. This should be verified from operating experience at nearby existing plants on the same stream. Where existing plants are remote or the project is on a previously undeveloped stream, a water analysis should be the basis of determining the likelihood of corrosion or scale deposits and the need of additional treatment. Typical strainer requirements for coolers permit 3-mm (1/8-in.) perforations, but strainer specifications for existing projects should be obtained as a guide to complete design requirements. Strainers should be the automatic type unless the system provides other backup provisions for continuous water supply or the p.h. is small. Unnecessarily fine strainers requiring more frequent servicing should be avoided. Filters are required for gland water unless the supply is the potable water system. The system should provide for continuous operation when an individual filter requires cleaning.

f. Pumps. A pumped cooling water supply requires a standby supply for a pump out of service. This can be provided with two pumps per unit, each of which is capable of supplying cooler requirements, or one pump per unit consisting of a common pump discharge header to all units and one or more backup pumps. Other arrangements to provide backup pump capacity may also be acceptable. Pumps should be located such that flooded suctions occur at minimum tailwater. Continuously rising pump performance curves are required, and the pump should not exceed 1,800 rpm.

g. Piping.

(1) Refer to Chapter 17 for general piping considerations.

(2) Water takeoffs from the spiral case or the spiral case extension should be within 30 deg of horizontal center line to minimize debris and air.

(3) A valve should be located as close to the casing as practicable for emergency shutoff.

(4) Balancing valves should be located in cooler supply lines.

(5) A removable 0.9-m (3-ft) section of straight pipe should be provided in the generator bearing supply line for temporary installation of a flow meter.

h. Drawings. Typical generator and turbine cooling water systems are shown in Figure B-7.

10-3. Transformer Cooling Water

Most plants now utilize air-cooled transformers, so there is very limited application of transformer cooling water systems. The general principles noted in paragraph 10-2 are applicable for transformer cooling water except where transformers are located on the intake deck of a dam-powerhouse structure. There the pumped supply would normally be from pool water rather than tailwater. Water pressure in heat exchangers should be less than the oil pressure to prevent water from entering the transformer oil under minor seepage conditions. Transformer cooling water systems must be protected from freezing where freezing can occur.

10-4. Fire Protection Water

The requirement for fire protection water is normally limited to deluge systems for main power transformers. Refer to Chapter 15, "Fire Protection Systems," for discussion of deluge systems. The deluge system water supply will normally be from the pool and should be a gravity supply if practicable. A booster pump should be provided if required. A pumped tailwater source is an acceptable alternate. Two water intakes are required either of which can supply the rated delivery of the pump. Consideration must be given to providing a source of power for pumping when the circuit breakers supplying the transformer are automatically tripped because of a transformer fault. The pump, piping, appurtenances, and installation should conform to the applicable provisions of NFPA Standard 851.

10-5. Potable Water System

a. General. The primary demand on the potable water system is drinking and sanitation water for the powerhouse. In addition, the potable water system is often used as the main source for gland and wearing ring water and, in some projects, supplies other potable water requirements, external to the powerhouse.

b. Water requirements. The powerhouse drinking and sanitation flow demand, including provision for visitors, should be determined in accordance with TM 5-810-5. This will normally be on a fixture unit basis. However, in the case of large powerhouses, the main rest rooms near the service bay are usually adequate for all personnel requirements, and additional facilities are provided, remote from the service bay, for convenience. These require the piping design on a fixture unit basis, but a reduction in the fixture unit basis water demand, commensurate with the intended usage, can be justified. Gland and wearing ring flow requirements are as determined under paragraph 10-2*b*(2). Principal quality requirements are safety in health considerations and acceptable taste qualities consistent with the area in which the project is located.

c. Sources.

(1) General. Sources for powerhouse requirements include the following: pool water, tailwater, powerhouse well, general project supply, existing construction supply, and local public supply. The order of preference depends on several variables, but it is generally preferable to supply all project potable water requirements from one system whether it be a powerhouse or nonpowerhouse source. All sources should be considered, and a choice made on the basis of reliability, purity, required treatment, and cost. For nonpowerhouse sources, the powerhouse design responsibility is limited but includes mutual verification of demand, supply, reliability and cost, and provisions for necessary standby sources.

(2) Wells. Good wells usually provide the best source of potable water from purity, treatment, and temperature considerations. The existence of good wells in the vicinity along with favorable geological indications would suggest serious consideration of a well supply. The system No. 1 well and storage reservoir should be adequate for all initial and potential expansion demands, and there should be a backup well at least adequate for system operation under conservation operation. In the evaluation of a potential well supply, other considerations should include the following: water rights; probability of increased domestic, agricultural, or commercial demand for underground water; and effects of pool raising and pool level variations. The power plant design analysis should include a record of all factors considered in the selection of a well supply.

(3) Pool or tailwater supply. Reliability is the major advantage of either a pool or tailwater source. Quality is usually questionable, and treatment plants providing coagulation, chlorination, sedimentation, and filtration may be required. It will usually be desirable to combine a pool or tailwater potable supply with other nonpotable, powerhouse raw water requirements as far as intakes, intake piping, and strainers are concerned. Intakes from either pool or tailwater should not be located in penstocks, unit intakes, or draft tubes in such a way that system water is not available 100 percent of the time.

(4) Construction source or public supply. An adequate existing construction source or public source is unlikely but should be investigated in view of the obvious advantages, particularly of a substantial, state-regulated system.

(5) General project supply. A general project supply may be from one or more of the previous sources discussed and may originate under powerhouse design or nonpowerhouse design. It will usually be the optimum arrangement for the project as a whole. If the design is nonpowerhouse, all powerhouse requirements should be

determined, and adequacy of the supply verified by the powerhouse design office.

(6) Factors. TM 8-813-1 provides a discussion of factors to consider in evaluating water supplies.

d. Pump versus gravity considerations (pool-tailwater source).

(1) High head projects. Projects with over 76-m (250-ft) head should be provided with a pumped potable water supply with the pumps taking water from a tailrace intake. Pressure-reducing valves to utilize gravity heads from higher pools are not recommended unless tailwater is excessively contaminated or not always available.

(2) Low head projects. Project with under 76-m (250-ft) head may utilize gravity head to good advantage, providing pool fluctuations will not result in less than 103-kPa (15-psi) pressure at the highest fixture served. Pressure-reducing valves with downstream relief valves can be used to provide a reasonably constant pressure if necessary. Temporary failure of a pressure-reducing or relief valve will not endanger fixtures or piping up to 76 m (250 ft) of head.

e. Pump requirements (pool-tailwater source). Pumped potable water requirements should be provided by two pumps with either pump capable of pumping the total system peak demand. Pumps should normally be either vertical or horizontal centrifugal with constant rising characteristic curves and should be located to ensure a flooded suction under all operating conditions. Turbine-type pumps should also be considered for low-flow higher-head requirements. Controls should be conventional lead-lag for a hydropneumatic tank or gravity tank as applicable. Unless the potable water pumps are pumping from a strained raw water supply, duplex suction strainers are required.

f. Water treatment. A water quality analysis should be obtained to determine the treatment required. In event that full treatment is not initially indicated, space, piping sizes, and connections should be provided to expand treatment facilities should subsequent changes in water quality so require. Power plant uses do not require all water qualities considered desirable for domestic use, so judgment in applying treatment criteria is necessary. Potable water should meet the minimum requirements as specified in ER 1130-2-407. For treatment plant design, refer to ASCE-AWA-CSSE published by American Water Works Association (AWWA). Other references include TM 5-813-3, applicable state plumbing codes, and EPA requirements.

g. Storage tank.

(1) Gravity tank. A gravity tank, or other gravity sources, with capacity and head to sustain the project for a week or more under conservation operation is the most desirable storage facility. When a suitable tank location is available, and particularly where there is a substantial nonpowerhouse project demand, design emphasis should give first priority to a gravity system. The design responsibility for the storage facility will usually be nonpowerhouse for such systems. Refer to TM 5-813-4 for water storage considerations.

(2) Pressure tank. Where a gravity system is not feasible, a hydropneumatic tank located in the powerhouse is normally provided for the powerhouse requirements. The tank should be sized so that in combination with high-average system demand and pump delivery, it will provide a minimum 30-min chlorine contact period and allow approximately 10 min between pump starts. Tanks should conform to Section VIII of the ASME "Boiler Pressure and Vessel Code." Tanks smaller than about 1,676 mm (66 in.) in diameter should be galvanized inside and out depending on plant capabilities in the supply area. Larger tanks should be painted inside and out.

h. Hot water.

(1) Powerhouse fixture requirements. The type, number, and location of fixtures requiring hot potable water are normally determined by architects. The piping system designer should cooperate in the planning to effect the most practical grouping of fixtures for efficiency of hot water distribution.

(2) Demand. Demand should be computed on the basis of Table B-2 and information noted in Appendix B, paragraph B-5, "Powerhouse Electric Water Heaters."

(3) Heaters. Heaters should be the electric tank type and should be selected in accordance with Appendix B, paragraph B-5. Where fixtures are isolated by more than 18-24 m (60-80 ft) of piping, the provision of separate heaters may be more economical and should be investigated. Electrical load should be coordinated with the electrical design.

i. Piping. Refer to Chapter 17 for general piping considerations. Disinfecting of potable water piping in accordance with AWWA Standard C 601 should be provided. Backflow preventers are required between the potable water system and gland water piping also in any other interconnection between potable water piping and piping with the potential for containing nonpotable water.

j. Drawing. Figure B-8 presents a plan of a typical potable water system.

10-6. Raw Water System

a. General. The raw water system normally provides water for the following requirements:

(1) Air compressors and aftercoolers.

(2) Air conditioning cooling water.

(3) Fire protection-deck washing.

(4) Pump prelube.

(5) Unwatering and drainage deep well.

In addition, certain projects may utilize water from the raw water system for gland water, transformer deluge system, station transformer cooling water, and a source for the potable water system.

b. Water requirements. Flow requirements for air compressors, aftercoolers, and pump prelube should be obtained from equipment suppliers and verified against existing projects with similar equipment. Air conditioning flows will be as computed for the air conditioning system. Fire protection - deck washing hose valve requirements should be based on 3-L/s per 40-mm (50-gpm per 1.5-in.) hose and should assume three hoses operating at one time. Quality requirements for the raw water system are nominal, requiring straining only unless water analysis indicates a need of treatment to limit scale formation in cooling coils.

c. Sources.

(1) General. Raw water should normally be obtained from the pool or tailwater. Other reliable sources are unlikely to be economically available; however, an existing or planned adequate gravity project source would offer some advantages and should be considered.

(2) Pool. For projects up to about 76-m (250-ft) head, a gravity pool supply is usually preferable.

(3) Tailwater. For projects over 76-m (250-ft) head, or where pool head fluctuates over a wide range, a pumped tailwater supply will normally be utilized. For high head projects in tidal locations with brackish tailwater, special materials and/or equipment will be required.

d. Head. Optimum head for raw water requirements can vary considerably depending on the particular equipment selected and its location. System design should consider the inherent flexibility in required differentials across coils and heat exchangers, as well as locations, to effect the simplest and most dependable system. The provision of booster pumps or pressure-reducing relief valve stations to provide different head in a portion of the system should be evaluated on the basis of requirement rather than desirability. The fire protection-deck washing hose cabinets are intended as backup fire-protection only, permitting reasonable fluctuations in available head.

e. Treatment. Strainer perforations of 3 mm (1/8 in.) will normally be adequate for all raw water system requirements (see paragraph 10-2*e* for further recommendations).

f. Pumps. The pump principles noted in paragraph 10-2*f* are generally applicable. The system design should provide standby pump capacity for all pumped requirements. For pumped tailwater systems, the raw water system requirements can be included in the generator cooling water pumps capacity and supplied through the crossover header, with booster pumps provided if required.

g. Piping.

(1) Refer to Chapter 17 for general piping considerations.

(2) The generator cooling water crossover header should normally be the supply to the raw water system.

(3) Where the generator cooling water is a gravity supply which is not always available, a standby raw water supply intake and piping should be provided.

(4) Piping for fire protection-deck washing hose cabinets subject to freezing should be provided with automatic drainage.

(5) A 20-mm (3/4-in.) hose valve should be provided at each turbine head cover for cleanup.

(6) A 40-mm (1.5-in.) hose connection should be provided near turbine access hatches to wash down the turbine.

h. Fire protection-deck washing hose cabinets. The fire protection-deck washing provisions are intended basically to meet the normal standards of a deck washing system and to further serve as a backup means of fire control. Powerhouses are considered to be low fire hazard structures with code fire protection provisions limited to generators, oil storage and pump rooms, paint storage rooms, and in some cases, transformers. Protection for these hazards are covered in Chapter 15, "Fire Protection Systems." To provide backup protection, the fire protection-deck washing system should include 40-mm (1.5-in.) hose connections, hose and reels, spaced throughout the powerhouse and decks, to permit minimum hose nozzle coverage of all occupied areas except drainage galleries and locations where a stream could contact high-voltage electrical equipment. Areas used for loading or unloading from vehicles or railroad equipment, heavy maintenance areas, potential storage areas, and where there is oil piping should be accessible to simultaneous hose-nozzle coverage from two directions. Where the fire protection-deck washing system is supplied by pumps, the pump and standby pump should receive power from separate sources.

i. Drawings. Figure B-9 shows typical raw water systems.